crystals, and in this paper I shall confine myself to the former.

We observe that a plane drawn through the direction of the ray or pencil and the axis of the crystal is called a principal plane. It is found that one of the two rays into which the incident ray is divided is refracted according to the ordinary law, and is therefore called the ordinary ray, the other according to a more complicated law, and is called the extraordinary ray. But we especially remark that the vibrations constituting the ordinary ray lie wholly perpendicular to the principal plane of the crystal, those of the extraordinary ray parallel to the principal plane. Consequently both rays will consist of polarised light, according to the definition we have just given of polarisation, and this polarised light will arise from the vibrations of the incident ray being resolved perpendicular and parallel to the principal plane.

Of all uniaxal crystals the best known is Iceland spar, which possesses the power of double refraction in an eminent degree. It occurs in the form of a rhombohedron, and the axis of the crystal corresponds with the shortest diagonal.

Now suppose a plate of this crystal, cut perpendicular to its axis, is interposed between the polarising and analysing plates, when the first and second planes of incidence are perpendicular to each other.

The colour of light depends on the length of the wave. The length of a wave of violet light is ·0000167, and that of a wave of red light ·0000266 of an inch. The wave-lengths of the other colours lie between these. White light is a compound of all colours, and therefore its vibrations are of all lengths lying between these extremes. It will therefore manifestly simplify the explanation we are going to submit to the reader, if we commence by assuming the light to be monochromatic, and its vibrations of the same length. Let a small pencil of monochromatic light, P (Fig. 1), be reflected from a plate of glass, A, at an angle of about 56°, pass through the crystal C, and then be reflected a second time from the plate B at an angle of about 56° in the direction B E. The plane P A B is supposed to be perpendicular to the plane of the paper, the plane A B E to coincide with it. The crystal is supposed to be bounded by parallel surfaces perpendicular to its axis, and in a position perpendicular to the line A B. Let *a b*, *c d*, be two straight lines drawn in the crystal, one in the plane of the paper and the other perpendicular to it. The eye is supposed to be placed at E.

The vibrations of light proceeding from A will all be parallel to the plane of the paper. In general, each ray as it enters the crystal will be resolved into two, and thus will arise two sets of waves which will interfere with each other. Hence a succession of dark and bright curves will be visible to an eye placed at E. Moreover, as the crystal is symmetrical round A B, it may be expected that these curves will be circular. It may also be expected that the diameters of the bright circles will depend on the length of the wave, and therefore on the colour of the light.

We have already defined the principal plane of the crystal for a given ray, to be the plane passing through the ray and through the axis of the crystal, which in this case coincides with A B. As therefore the vibrations of the rays incident on the crystal are all parallel to the plane of the paper, those which enter the crystal along *c d* are all perpendicular to a principal plane of the crystal, and those which enter it along *a b* are all parallel to a principal plane. Therefore every ray which enters the crystal along *a b* and *c d*, will be transmitted to the second plate unresolved, and unchanged, and will therefore be incapable of being reflected to an eye situate at E. Consequently a dark cross will appear to the eye at E, corresponding to the lines *a b*, *c d*, intersecting the system of rings we have just described. Now suppose white light to be substituted for monochromatic light. White light is composed of light of all colours, and we have seen that the diameters of the bright rings are different for each colour. Consequently, instead of dark and bright rings, we shall have a series of coloured rings intersected by a dark cross. This phenomenon is shown in Fig. 2.

If the second plate be turned round an axis in the direction A B, till the first and second planes of reflection coincide, the reader who has followed this investigation will perceive that the dark cross intersecting the rings will be changed into a white cross. This bright cross is shown in Fig. 3.

If the second plate is turned round the same axis into any position intermediate to those we have just described, the rings will be intersected by two crosses, inclined to each other at an angle equal to that between the planes of first and second reflection. There will be coloured arcs between the crosses, but those distances which give a maximum light for the arcs outside the crosses will give a minimum light for the arcs inside the crosses. This phenomenon is shown in Fig. 4. These are the appearances observed when the surfaces of the crystal plate are perpendicular to the axis of the crystal, and to the axis of the incident pencil. Dr. Ohm has investigated the phenomena which occur when the axis of the crystal is inclined at any angle to its surface, and the crystal itself is placed in any position between the polarising and analysing plates. His mathematical investigations will be found in the seventh volume of the "Munich Transactions," and the following are the principal results which he has obtained.

We shall suppose the light monochromatic. There will be a succession of dark and bright curves which are either parabolas, ellipses, or hyperbolas. For a given position of the crystal, the ellipses and hyperbolas are concentric; but the centres are never in the centre of vision, unless the axis of the crystal is either perpendicular or parallel to its surfaces. When the bright curves are parabolas, their vertices are equidistant from one another. When the bright curves are ellipses or hyperbolas, the difference of the squares of the semiaxes of two consecutive curves is a constant quantity. We have seen that when the axis of the crystal is perpendicular to its faces, the bright curves are circles. As we cut the plates so that the axis may be inclined at angles more and more acute to the surfaces, the bright circles become ellipses, which elongate continually till they become parabolas.

Suppose two plates of crystal, with parallel surfaces of equal thickness, and with their axes inclined at the same angle to the parallel surfaces, be placed in contact, so that their axes may lie in the same plane, but not in the same straight line, and then introduced between the polarising and analysing plates, a succession of dark and bright ellipses and hyperbolas, with their centres in the centre of vision, will be seen. It was this experiment which led Dr. Ohm to the results we have endeavoured to lay before the reader.

W. H. L. RUSSELL

NOTES

TWELVE months ago the Erdington Orphanage, founded, built, and endowed solely by Mr. Josiah Mason, at a cost of nearly 250,000*l.*, was opened at Birmingham. Mr. Mason, exactly following the example of Mr. Peabody, has now in contemplation another public work of even greater ultimate importance, namely, a college and schools for scientific and technical instruction, open to all classes, and if the hopes of the founder should be realised, capable of expansion into one of the noblest institutions in the kingdom. As yet the plan is only broadly formed, and some time must elapse before it can be carried into effect; but the *Birmingham Daily Post* states that a beginning has been made, and that for the purpose above mentioned, Mr. Mason has agreed to buy a large block of land in Edmund Street, exactly facing Ratcliff Place, between the Town Hall and the Institute, and reaching back to Great Charles Street. The purchase money, we believe, is more than 20,000*l.*, a magnificent earnest of the ultimate scheme which Mr. Mason has in contemplation. We make this announcement with the greatest pleasure, and ask—Why are citizens who thus consecrate their wealth to such noble and enlightened purposes so rare when their reward is so great?

The following are the arrangements for the approaching fortieth annual meeting of the British Association for the Advancement of Science, to be held in Liverpool, commencing on Wednesday, Sept. 14. President-elect—Professor Huxley, LL.D., F.R.S. Vice-Presidents-elect—The Right Hon. the Earl of Derby; Right Hon. W. E. Gladstone, M.P., D.C.L.; Sir Philip G. Egerton, Bart., M.P., F.R.S.; Sir Joseph Whitworth, Bart., LL.D., F.R.S.; S. R. Graves, Esq., M.P.; J. P. Joule, Esq., LL.D., F.R.S.; Joseph Mayer, Esq., F.S.A. Chairman of Local Executive Committee—The Mayor of Liverpool (Joseph Hubback, Esq.) Local Treasurer—Henry Duckworth, Esq., F.G.S. The sections are—(A) Mathematics and Physics; (B) Chemical Science; (C) Geology; (D) Biology; (E) Geography and Ethnology; (F) Economic Science and Statistics; (G) Mechanical Science. These will meet each day from eleven to three o'clock, in St. George's Hall, the Town Hall, Free Public Library, and other places to be duly announced. General and Evening Meetings—Wednesday, Sept. 14: The first general meeting will be held in the Philharmonic Hall, at 8 P.M., when Professor Stokes, M.A., D.C.L., will resign the chair, and Professor Huxley, LL.D., F.R.S., will assume the Presidency and deliver an address. Thursday, Sept. 15: The Mayor's First Reception at the Town Hall. Friday, Sept. 16: Lecture in Philharmonic Hall, at 8.30 P.M., by Professor Tyndall, LL.D.; the Mayor's Second Reception at the Town Hall. Saturday, Sept. 17: Address to Working Men, in Concert Hall, Lord Nelson-street, at 8 P.M., by Sir John Lubbock, Bart., M.P., F.R.S. Monday, Sept. 19: Lecture in Philharmonic Hall, at 8.30 P.M., by Professor Rankine, LL.D., F.R.S. Tuesday, Sept. 20: Soirée in St. George's Hall, at 8 P.M. Wednesday, Sept. 21: Concert in St. George's Hall, at 8 P.M. Thursday, Sept. 22: Excursions to several places. Members requiring further information should apply to any of the following Hon. Local Secretaries—Wm. Banister, B.A.; Reg. Harrison, F.R.C.S.; H. H. Higgins, M.A.; A. Hume, D.C.L., LL.D., Municipal-buildings, Dale-street, Liverpool.

Professor Winlock is now engaged in photographing the sun on a plan which, so far as we know, has not before been put into practice. He uses a single lens object-glass, 4½ inches diameter, 40 feet focal length, of crown glass, made by Clark, and corrected for spherical aberration by means of an artificial star of homogeneous (sodium)-light in the focus of a 5-inch collimator. The image of the sun is 4¼ inches in diameter. The tube of the telescope points to the North, and the image of the sun is thrown in by means of a reflector of plate glass. This glass is *not* roughened or blackened on one side, because when that was done the heat of the sun distorted the plane surface. The slit is at the object-glass end of the telescope, and that position has the advantage that when it is thrown across no dust is shaken down on to the plate, as is apt to happen in the usual way of working. It is Mr. Winlock's intention to photograph the sun every fair day now. It seems also probable that this mode of photographing might be of advantage for the partial phases of an eclipse.

Mr. H. Power, M.B. (Lond.), and Mr. B. J. Vernon have been appointed ophthalmic surgeons to St. Bartholomew's Hospital.

Dr. Lapeyrere insists in the *France médicale*, on the desirability of disposing of the bodies of the slain during the Franco-German war by incremation rather than sepulture. Although there is a feeling against this mode of obsequy during present times, he points out that it was practised by the most civilised nations of antiquity. The burial of the dead after a battle is always a difficult task; it is probably never done so completely as to destroy the probability of the tainted air giving rise to all kinds of infectious diseases; and when we recollect the enormous masses of men concentrated in a small space in the present conflict, and the season of the year, the matter becomes one of very serious moment.

The fearful destructiveness of so-called "natural" causes of death, as compared with even the most sanguinary battles, is shown by the fact that during the siege of Sebastopol, the French army lost 20,240 men by death in the field or as the result of their wounds, 75,000 from epidemic and other diseases. During the Italian campaign of two months, the French losses were 3,664 killed or mortally wounded, 5,000 from disease.

There was a shock of earthquake on the 12th July at Smyrna. It was not very strong, but lasted a considerable time. The previous shock was on the 24th June, and was felt at different parts of Asia Minor and in Cyprus, Crete, and Egypt. Of the July shock there were only particulars at the last advices of its having been felt at Aivali and some other inland points of Asia Minor. We learn further that the earthquake of the 24th June was felt at Damascus at $6^h\ 15^m$ P.M. It was felt also in the town of Zebedani in the Anti-Lebanon, N.W.

The Geological Survey of Italy will begin its regular definitive work next August. Commencing with Florence, it will first of all complete the study of a portion of that province. As the Ordnance map on the scale of 1 to 50,000 is not yet completed, the Geological Survey will make use of the map made by the Austrian Ordnance surveyors on the scale of 1 to 86,400, enlarged by photography to the scale of 1 to 50,000.

Whatever claims Sir Christopher Wren may possess to be considered the originator of the Thames Embankment, it is hardly fair to leave out of sight those which belong to Sir John Kiviet. The latter gentleman was a refugee from Rotterdam who came to England in 1666, and possessed some of the ingenuity of his brother-in-law Admiral Van Tromp. It does not appear how soon after the Fire of London it occurred to Sir John to propose a river embankment, but as early as 2nd December, 1666, we find him examining the soil of the foreshores with a view to discovering whether it was suitable for making clinker-bricks. On the 6th of March following Evelyn definitely proposed to the Lord Chancellor "Monsieur Kiviet's undertaking to warfe the whole river of Thames, or Key, from the Temple to the Tower, as far as the fire destroied, with brick, without piles, both lasting and ornamental." We may presume it was favourably received by Lord Clarendon, as upon the 22nd of the same month Evelyn had audience of the King with reference to building the Quay, and a few days later Sir John Kiviet and the Diarist "went in search for brick earth in order to a greate undertaking." No further mention is made of the scheme, and we may perhaps conclude that it was abandoned either on account of the unpopularity of the inventor (whose Dutch extraction would at that time have been a natural bar to success), or of the fall of Clarendon at the ignominious close of the war with Holland. At any rate, Kiviet has some right to divide the honours with Wren, though, in view of the work just completed, we cannot regret that its execution was reserved for our own times.

The *Food Journal* for August, which contains some excellent articles, thus sums up the possible influence of War on our food supplies:—"*Free trade in live-stock* is by no means synonymous with *free trade in meat.* France will now get meat whence she cannot get live-stock. Her soldiers and sailors will eat the salt beef and pork of Cincinnati, Chicago, and St. Louis.

Prussia will probably suffer—she will certainly suffer if the war be prolonged—from her native animals being stricken by contagion; and England, that has hoped so long and so much from the resources of the East, will be left to seek for plenty in her own evergreen fields, and trust that some day her pre-eminence over the seas may render her independent of the transportation of a few hundred bullocks and sheep weekly from shores nearest her, by securing the produce—dead, not alive—of healthier, though more distant lands."

THE *Pharmaceutical Journal* (which now appears weekly) states that the plans for the erection of a Pharmaceutical Institute in connection with the University of Marburg have been approved, and the work was to have been commenced at once, but will now probably be delayed by reason of the war.

A COMMITTEE, appointed by the Royal Medical and Chirurgical Society to investigate the hypodermal method of administering injections, has just presented its report, on which the *Medical Times and Gazette* remarks:—"We may safely take, as a broad guide in practice, the rule that the physiological activity of nearly every substance which can thus be used, is three, if not four times greater when it is given by the skin than when it is swallowed." The proper commencing dose of strychnine is $\frac{1}{120}$ grain of the sulphate. The dose of atropine is also $\frac{1}{120}$ grain at first. The dose of morphia is $\frac{1}{10}$ grain to $\frac{1}{6}$ grain.

A TRANSLATION of Professor Huxley's Elementary Lessons in Physiology has just been brought out in Paris, edited by Dr. Dally, who introduces it as "*La Science sans Phrases.*"

THE following parliamentary papers have been recently issued:—Second Report of the Rivers Pollution Commission (discussing the A B C process of treating sewage); report of the Meteorological Committee of the Royal Society for the past year, an important document to which we shall return; and Volume VII. of the Irish Primary Education Commissioners' report.

SOME standard photographs and directions for measurement have been received by the Colonial Office from the Ethnological Society, through Prof. Huxley, the president. These are intended for the measurement and descriptions of aborigines in our Colonies.

THE Statistical Society has under consideration the means of promoting the study of political economy and of the numerical and statistical mode of investigation by granting prizes in our public schools. The first step will be to obtain the opinions of the head masters. The success of the Royal Geographical Society's examinations is an encouragement for this new effort.

OIL seeds having proved such a valuable branch of commerce in India, the Government is trying to promote the gum trade. The plants of the Australian gum tree, the *Eucalyptus*, introduced into the Punjaub, are taking well. It is hoped the gum will be of equal quality to the fossil *Damara Australis*, or New Zealand *Kauri pine*.

COAL containing 68 per cent. of carbon is reported to have been discovered near the town of Darjeeling, in the hill district of the Himalayas. Valuable copper and iron have also been discovered, so that important English settlement has the chance of other resources beyond tea and cinchona. The development of the minerals promises in time to give further employment for English settlers. At present in the hill regions the only metal working is in the iron mines of Kumaon. The hills can supply fuel for working charcoal iron. Our newly-annexed Bhootan territory is supposed to contain iron.

NOTWITHSTANDING the financial raid, the Lieutenant-Governor of Bengal has directed that nothing shall be done in the way of disbanding the establishment assigned for the survey of the Khasi, Naza, and Garrow hills, but, on the contrary, that the survey operations shall be taken up whenever the reduced strength of the staff will admit of it. The Government of India has confirmed this decision.

THE last scientific curiosity is a "Statement of a recently claimed discovery in Natural Science, incentive to mining enterprise," compiled by "Research," who endeavours to prove that geologists are entirely wrong in teaching that the changes in the ocean-line are due to continuous slow elevation or subsidence of the land. It appears that these changes are really due to shiftings of the mass of water in the ocean resulting from "a change of the centre of gravity of the earth's volume;" though how a knowledge that we are at any time liable to a sudden overflow of the waters of the ocean can be "an incentive to mining enterprise" is not clearly shown.

AMONG the novelties in the Exhibition at Paris in 1867 was the American Gatling gun, which, it was asserted, was to revolutionise the art of war. Like the mitrailleuse, the Gatling has as many locks as it has barrels. But whereas in the mitrailleuse the barrels are fixed and the locks have only a horizontal motion, in the Gatling both locks and barrels revolve. The locks have also, when the gun is at work, a reciprocating motion. The cartridges are kept in "feed-cases" side by side, and transferred to a "hopper," or shoot, when they are to be used. A handle is turned, and a process goes on analogous to that of the bullet-making machines, well known to visitors of the Royal Arsenal at Woolwich. When a ten-barrel Gatling is being fired, five of the cartridges are in process of loading and firing, five in process of extraction after discharging their bullets. The locks play backwards and forwards in the cavities where they work, and if one becomes disordered the action of the others is not stopped, provided that everything acts as it ought. Three sizes of Gatlings are generally made, the largest throwing a projectile of about half a pound weight. Case shot are made for the large-sized Gatling as well as solid bullets. It is, however, too heavy, and requires four horses. The chief defect of the Gatling, of all sizes, is that it cannot, like the mitrailleuse, fire volleys, but only single shots, always in the same line.

TWO experiments have recently been tried with a gunpowder invented by M. Pertuiset—the first by the Austrians against iron plates at Pola; the second recently in London. The former were made last September, in continuation of a series commenced some time before. The target was intended to represent the side of a first-class ironclad ship. There were two plates, one of 4·5 inches thick, the other 4·75 inches, English measure. The backing was 10 inches of hard wood, then an iron skin 1·5 inches thick, and behind it 12 inches of oak. The gun was of 8 inches calibre; the charge was 12 kilogrammes of common powder. The projectiles were of cast iron, made in Austria. They weighed 90 kilogrammes, and those intended to explode contained 1,500 grammes of Pertuiset powder. Two solid shot were first fired at the target, and only indented the face of it. The first of M. Pertuiset's shells not only broke the front plate and damaged the backing, but dislodged a mass of iron 22 inches by 15. The second round struck on a sound plate, and not only destroyed the iron, but so smashed the backing as to render the target unfit for further experiments. The opening in the front plates was this time far more considerable than after the first round. The experiments in London were made on horses. The skull was split, and on handling it large pieces of bone came away easily. The surface bones were removed, and the brain beneath was found to be utterly destroyed—a mass of gray and white matter devoid of consistency. When the loose material was lifted out there was a hole like the crater of a mine, 7 inches long by 6 broad. Part of the bullet had been driven up to the back of the head. And this work was done by a weapon that a man can carry in his pocket!